



MySQL Enterprise Backup

Fast, Consistent, Secure, Online Backups

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Introduction

Organizations are facing an expanding set of data protection challenges. Not only do they rely on database applications for every area of their business including sales, customer service, finance, marketing, manufacturing and human resources, but many of these applications need to be available 24x7. At the same time, the volumes of data that need to be managed are growing exponentially putting added pressure on available storage and storage costs.

Implementing proper database backup and disaster recovery plans to protect against accidental loss of data, data theft, database corruption, hardware/operating system crashes or any natural disasters has become one of the most important responsibilities of the Database Administrator (DBAs). Unfortunately, if you don't have an adequate database backup and recovery strategy and implementation in place then you are left with nothing to fall back on.

As a DBA you need to make sure that the databases are backed up regularly and timely recovery procedures are in place and tested. MySQL Enterprise Backup provides DBAs with a high-performance, online "hot" backup solution with data compression and encryption technology to ensure your data is protected in case of downtime or an outage.

Database Backup Terms

Before we dive into backup strategies and methodologies let's first cover some backup and recovery terminology.

Online Backup – An online or "hot" backup is a backup that can be performed while the database is running. Read and write operations can continue while the database is being backed up. There is no need to shutdown the database or comprehensively lock database files.

Incremental Backup – An incremental backup is a backup that only contains data that has changed since the last complete full backup. An incremental backup takes less time and requires the least amount of storage space.

Partial Backup – A partial backup is a backup of only part of the database such as selected tables.

Consistent Point in Time Recovery – Consistent Point in Time recovery enables recovery of a database to a consistent state at a specific target time.

Roll Forward Recovery – Roll forward recovery makes it possible to restore a database to the most recent state before a failure occurred.



Requirements Assessment

In order to develop a backup strategy you must first assess your needs. Your backup and recovery implementation will depend on a lot of factors including value of the data, data change frequency, industry regulations, corporate governance and many more. Here are some questions to ask yourself in order to get started:

- *What point in time do I need to recover to? Is it a week, a day or hour or minute?*

This is referred to as the Recovery Point Objective (RPO). It is the point in time that the restarted database will reflect. What you define as the RPO will depend on your business, how critical the data is and how frequently your data changes. Your RPO will help determine what types of backups you need to run and how frequently. Another important question to ask yourself is:

- *When I have a failure, how quickly do I need to get back online?*

This is referred to as the Recovery Time Objective (RTO). It is the amount of time elapsed between the outage and restoration of your database. Answering these 2 questions will help you to start to formulate a data retention policy.

- *How sensitive is the data in the database?*

Its just as important to secure your backup image as it is to secure your databases. If stolen all data is in the backup, therefor its often quite important to protect the image with encryption.

- *Where am I going to store the backup?*

Is your backup local to the server, what if the hardware fails. You may want to store backups locally, in Cloud Storage (Oracle Cloud Store, AWS S3, OpenStack Swift), or to media managers build for backup storage (directly to products such as Oracle Secure Backup, Netbackup, Tivoli Storage Manager or Networker)

In addition to these questions, your data retention policy may also be driven by regulations or corporate governance requirements, which may dictate where and how long you need to keep historical data as well as encryption requirements. Other considerations what come into play are storage requirements and storage availability. If data sizes are in the terabytes range or more, the cost of backup storage needs to be weighed against budgetary constraints.

Database Backup Methods

Lets take a look at the different backup methods you can implement to help achieve your backup strategy. There are many different backup methods but lets take a look at 4 primary backup methods you can use with MySQL Enterprise Backup.

Full Backups

Full backups make a complete copy of your data. If you don't have to recover to a specific point in time, then a strategy of using only full backups will fit your needs. For example, you can run full backups on a daily basis or even on a weekly basis if your data does not change frequently or is not critical and you can afford to lose a few days of data.



MySQL Enterprise Backup also gives you an option to compress your data if you are faced with storage limitations. In addition, you can move your full backups to tape for archival purposes if needed.

Full + Incremental Backups

Complementing full backups with incremental backups enables you to run more backups, more often and reduce recovery time to within a few hours of when a disaster or corruption occurred. Since incremental backups don't require as much disk space, organizations can reduce their storage requirements and costs. Using this method also gives you the option of moving the full backups to tape while retaining incremental backups on disk. The incremental backups can then be deleted over time to clear disk space.

Full + Incremental + Log

If you need to return to within a few minutes or get back to a very specific point in time of when a disaster or corruption occurred, then combining a full backups and incremental backups with a backup of the transaction log is a good fit. This allows you to apply a full backup, incremental backup and roll forward prior to the point in time when the disaster occurred using the backup of the transaction log.

Optimistic - Full and Incremental Options

Optimistic backup is a backup methodology option that optimizes backup and recovery based on database update patterns where some tables (or partitions within a partitioned table) are infrequently or irregularly updated, or updated in isolation from the backup time. In many cases Optimistic reduces backup time, overhead, and size as well as recovery time. If you have a database where a large number of tables are infrequently updated, not updated when backups are running, or only have a percentage of tables that are frequently updated, Optimistic may be a good option for you.

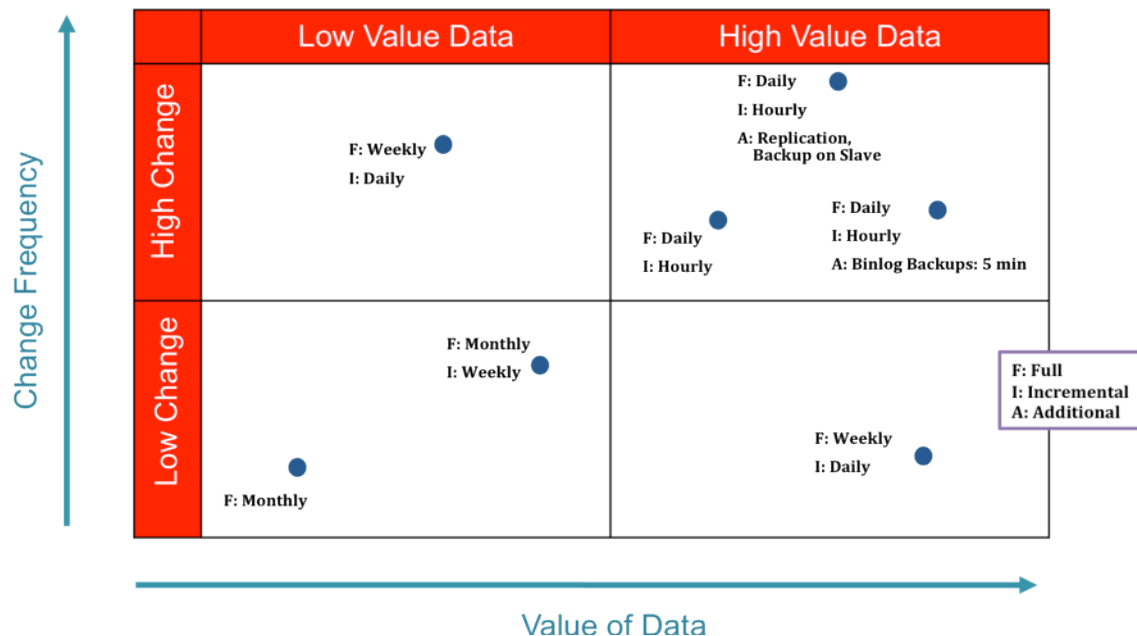


Determining Your Backup Strategy

Choosing backup type and schedule

When you formulate your backup strategy and try to decide which backup methods to implement, you need to look at least 2 or maybe more criteria to define your backup strategy. Two popular criteria are:

- Change Frequency of Data
- Value of Data



The illustration above provides some guidelines for choosing your backup method. For example, if your data only changes infrequently, such as every few months, then a full monthly backup might be all you need. On the other hand, if you have transactional data that is changing continuously and it is critical high value data then you should consider daily full backups, hourly incremental, combined with binary log backups. You may also consider doing backups on a replication slave if the master is burdened with heavy traffic. These criteria, along with the size of the data, RPO and RTO are going to help you formulate your backup strategy.

Additional Features

Encryption

If there is sensitive data within the databases, there is sensitive data within the backup. If you use MySQL Transparent Data Encryption then encryption is required. Even if TDE is not in use, you may still want to use encryption to secure your backups. Data can be stolen from unencrypted backups, and often the storage location for backups could present softer attack vectors. Many regulations and laws require encryption of backups. The minimal overhead when running encryption often goes unnoticed.

Compression



There are many advantages to compressing your MySQL backup, the most obvious is smaller size. However there can be additional benefits such as reduced backup time, less IO overhead, and reduced recovery time. This can be especially noticeable when writing backups to slower media or over the network. Compression also works well with MySQL Encryption so consider using both options together.

Optimistic

If you have a MySQL database where updates are focused on a select set of tables or table partitions, or tables are only updated during certain time intervals, the optimistic full and incremental backup may result in shorter backup and restore times. Optimistic guarantees a consistent backup and includes a few options to set to characterize your database usage patterns, thus providing greater backup and restore efficiency.

Backup and Recovery Attributes

Each Backup Method has different attributes that an organization should consider when developing their backup strategy. For example organizations should consider:

- Backup Time
- Restore Time
- Recovery Grade
- Storage Requirements
- Storage Limitations

The table below describes the various backup and recovery attributes associated with the backup methods described above.

Backup Method	Backup Factors	Recovery Factors
Method 1: Full Backups	<ul style="list-style-type: none">• Longest Backup Times• Largest Storage Space• Save space with compression	<ul style="list-style-type: none">• Easy to Recover• Fastest Restore Times
Method 2: Full + Incremental Backup	<ul style="list-style-type: none">• Reduced Storage Requirements• Requires 1X production storage for copy	<ul style="list-style-type: none">• Finer-grained Recovery• Slower Restore Times• First Restore Full Backup• Then Restore Incrementals
Method 3: Full + Incremental + Log Backup	<ul style="list-style-type: none">• Added Storage Requirements• Requires more than 1X production storage for copy	<ul style="list-style-type: none">• Finest-grained Recovery• Slowest Restore Times• First Restore Full Backup• Then Restore Incrementals• Then Apply Logs
Method 4: Offload Backups Slave Replication	<ul style="list-style-type: none">• Used with 1 of the above• Frees Master for more workload• Requires 1X production hardware and storage for standby database	<ul style="list-style-type: none">• Fast failover to standby• Backups are last resort, in event of double site failure or need to perform PITR



MySQL Enterprise Backup

MySQL has run many polls and surveys that indicate the importance of online backup. Over the years, online backup has been the #1 requested feature that MySQL users want. Among the biggest concerns are:

- Time duration for doing backup
- Time duration for doing recovery
- Performance impact on the database.

MySQL Enterprise Backup provides a rich set of back and recovery features and functionality including significant performance improvements over existing MySQL backup methods.

Backup	
Non blocking	"Hot" Backups of InnoDB tables takes place entirely online, without blocking
Optimistic Backups (supports Full and Incremental)	Uses attributes of data activity to provide an optimized backup - smaller, faster, less overhead
Incremental backups	Only backup the data that changed since a prior backup
Streaming backups	Redirecting a backup to stdout or to a pipe
Compressed backups	Reducing storage requirements up to 90%
Parallel Backup Operations	Performance, time reducing parallel multi-threaded processing
Direct to tape	Support for Secure Backup to Tape (SBT) interface for Tape and other Media Managers
Hot and cold backup support	Backups can be performed with MySQL online or offline
Binlog and Relay log backup	With optional switch simplifies and reduces time required to clone master into slave/replica servers for HA and replication
Continuous monitoring	Continuously watch and monitor the progress of a backup
Complete "full instance" backup	Additionally includes configuration and other information needed to create a matching replica
Skip Unused Pages	Saves space and IO by skipping unused pages within InnoDB data files
Selective backup	Uses highly performant and transportable method to backup tables by leveraging MySQL 5.6 Transportable Tablespaces
Single File backup	Writes the complete backup to a single file, stream or pipe
Exclude Tables	Exclude unnecessary tables from your Backups, saving backup time and space
Advanced LZ4 Compression	Support highly efficient, low impact and ultra fast LZ4 compression, as well as LZMA and zlib
AES 256 encryption	Built in 256-bit Advanced Encryption Standard (AES) encryption to secure all the sensitive backup data
Support MySQL TDE	Enables secure archival quality backup and restore of TDE encrypted database files and keys
Recovery	
Consistent Point-in-Time Recovery (PITR)	Recover and roll forward to a point in time

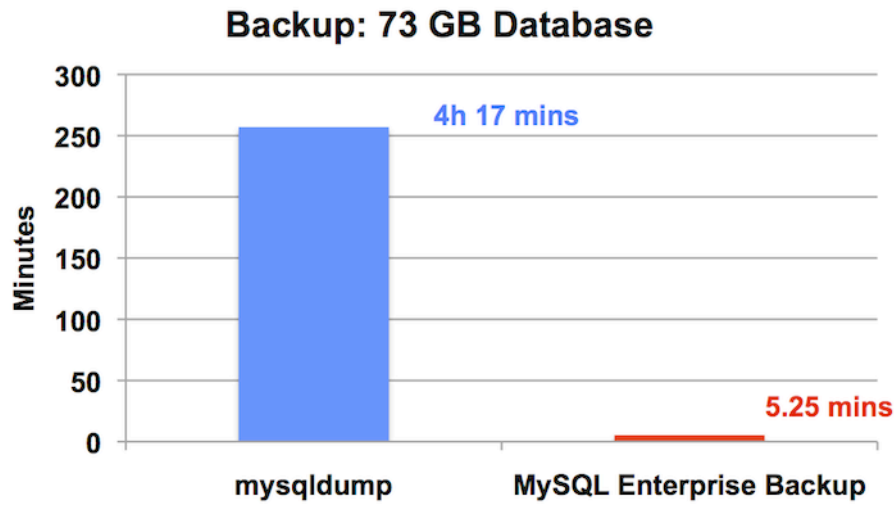


Parallel apply-log	Applies redo log changes in parallel
Partial Restore	Restore of particular tables or tablespaces
Restore to a Separate Location	Move database files on restore, create clones for fast replication
Familiar command-line behavior	Consistent MySQL parameters and interaction
Direct restore	Restore in a single step. Simplifies recovery and saves space
Selective TTS restore and table rename	Great for transporting and restoring large to very large tables from one database to another, or for partial recovery to stage a table and recover specific data
Streaming restore of partial backups	Partial backups taken using TTS can be restored directly from one server to another online server
Consistent Point-in-Time Recovery (PITR)	Recover and roll forward to a point in time
Advanced Features	
Throttling	Spread the load out over time and reduces peak utilization
OS buffer optimizations	Improves performance and avoids swapping
Export tables/tablespaces	Fine grained backup and recovery
Corruption Detection	Checks page checksums when copying InnoDB data and log files
Task Synchronization	Allows point-in-time task synchronization of other tasks with backup
Unlimited database size	Scalable, works well for small to very large databases
Runs outside MySQL process space	Lowers risk and increases performance
Scriptable Interface	Easy to use and simple to schedule
Low space detection	Monitors disk space and provides optional actions if space is low
Multi-platform	Linux, Windows, Mac & Solaris
Easy installation	Simple to install and deploy across the enterprise
Advanced Output Logging	Redirect messages to a log file. Helps in customer support and defect analysis
Custom Progress, Status, and Error Logging	Flexible logging options allows progress, status, and error messages to be teed and directed. Ideal for enhanced workflow into monitoring or for advanced logging integration
Additional Storage Engines	
MyISAM backups	Backs up MyISAM tables allowing applications to read data during backup
Other Storage Engine backups	Support Merge, Partition, Archive Engine backup
Integration with Popular Backup Solutions	
Direct to tape	Support for Secure Backup to Tape (SBT) interface for Tape and other Media Managers
	use SBT for integration with Oracle Secure Backup
	use SBT for integration with Veritas (previously Symantec) NetBackup
	use SBT for integration with Tivoli Storage Manager
	use SBT for integration with EMC NetWorker



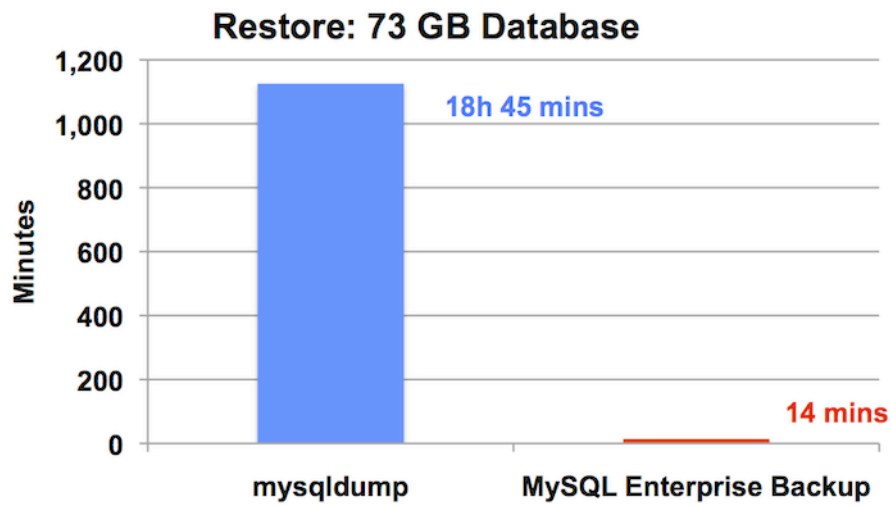
Performance

Let's take a look at some performance benchmarks for MySQL Enterprise Backup. The charts below summarize the performance of MySQL Enterprise Backup compared to mysqldump for backup and restore operations. The backup benchmark compares the number of minutes it takes for a full backup for 26GB and 32GB databases. As you can see, MySQL Enterprise Backup delivers 3.5x better performance for a 32GB database. Individual performance will depend on the complexity of your data model, but you can assume a significant performance increase for backups using MySQL Enterprise Backup.



MySQL Enterprise Backup delivers 49x better backup performance for a 32GB database

Backup is only half of the picture, recovery performance is often more important and where MySQL Enterprise Backup provides even greater benefits and where you will see the largest performance advantage for MySQL Enterprise Backup. Online recovery of MySQL Enterprise Backup is 80x faster than mysqldump, enabling you to significantly reduce your Restore Time Objective (RTO). In addition, recovery using mysqldump is non-linear because indexes and tables need to be recreated. One of the reasons why MySQL Enterprise Backup is so much faster is that there is little to no reorganization processing upon restoring the database.

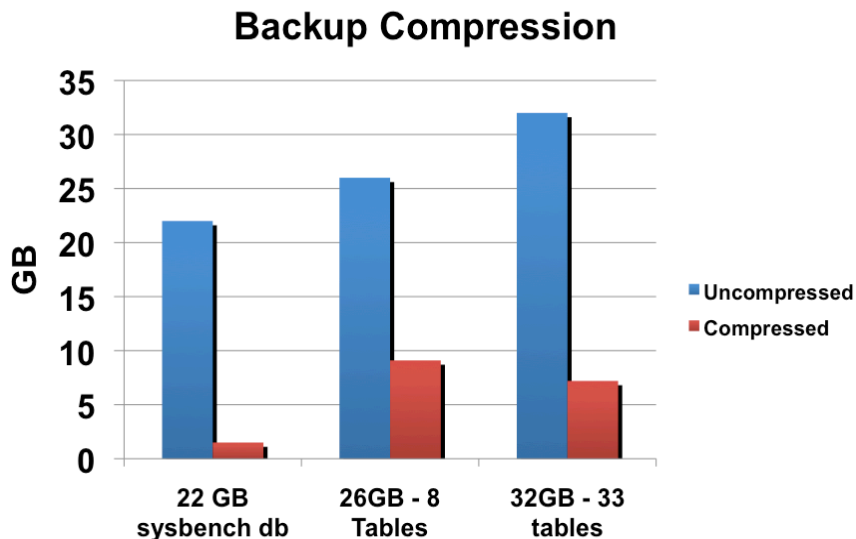


MySQL Enterprise Backup delivery 80x better recovery performance for a 32 GB database.



Compression

MySQL Enterprise Backup offer data compression that can help organizations save on storage costs. Advanced LZ4 compression provides highly efficient, low impact and ultra fast LZ4 compression, as well as LZMA and zlib. As you can see below MySQL Enterprise Backup can save from 65% to 93% reduction in storage space.



MySQL Enterprise Backup compression reduces backup size between 65% and 93%.

MySQL Backup Comparisons

Let's look at the advantages and disadvantages of various MySQL Backup options. In many cases, this is not an "either/or" decision. Your solution may include multiple methods.

MySqlDump and MysqLpump: Logical Import/Export

Advantages

- **Easy to use** - simple commands allow you to easily backup and restore
- **Good for small database or tables** – minimum impact on backup and restore performance
- **Flexibility** – logical backup allows you to choose what you want to backup and not backup.
- **Good assurance that database files are not corrupt** - all the data is read and it is read using standard SQL queries.
- **Logical – works cross platform**

Disadvantages

- **Not an online solution** - write operations are locked while performing the backup, thereby blocking use of the database.
- **Poor performance for larger databases** – backup and especially restore times are very slow for larger databases.
- **Not consistent** – database won't necessarily be restored to a consistent state.



- **No incremental backup** – all backups are full backups, can be time consuming and require more storage.
- **Locking** – requires locks on tables which can bottleneck application when running.

MySQL Replication: Standby Copy

MySQL Master Slave Replication allows users to fail over to a slave in case a master server fails. It is not a pure backup solution but rather a recovery tool that can be very valuable to recover quickly from a master hardware failure or software problem.

Advantages

- **Rolling snapshot** – users can revert to when database snapshots were taken
- **Quick recovery** – if master fails users can quickly recover and fail over to slave
- **Non blocking** – master is not blocked while replication snapshot is taken
- **Complements other backup options** – works well with other backup technologies.

Disadvantages

- **Backup is only latest point in time** – can't roll forward to specific point-in-time
- **Doesn't protect from user error** – user errors (e.g. dropped tables) are also replicated to slaves.
- **Not an archival backup** – not suitable for historical purposes

LVM Snapshots

LVM snapshots provide a complete, physical copy of the actual MySQL database/table files. ZFS and SAN systems also have mirrored snapshot options to apply for backup purposes.

Advantages

- **Fast** – Snapshot time is not dependent on the size of the database
- **Feature of Linux** - LVM has built-in snapshot functionality
- **Complements other backup options** – works well with other backup technologies.

Disadvantages

- **Point in Time Snapshot** - still need to make a backup copy of snapshots if you want to keep them.
- **Size** – Snapshot backup copies are equivalent to a full backup in size.
- **Performance** - too many concurrent snapshots will degrade performance
- **Portability** - doesn't work across file system so that could lead to inconsistencies.

MySQL Enterprise Backup

MySQL Enterprise Backup performs online "Hot", non-blocking backups of your MySQL databases. Consistent Point-in-Time Recovery (PITR) enables DBAs to perform a restore to a specific point in time and backup compression reduces backup size from 70% to over 90% helping organization reduce storage costs.

Advantages

- **Performance** – Up to 3.5x faster for backups and 16x faster for restore than mysqldump



- **Flexible** – support for incremental backups, partial backups, backup compression, point in time recovery and more.
- **Archival Backups** – suitable archival format for historical purposes
- **Scalable** – performance is near linear for larger databases.
- **Consistent** – delivers consistent point in time recovery
- **Secure** – includes encryption to protect backup images from theft
- **Media Support** – backup to filesystems, Cloud Storage, Media Managers/Tape
- **Supported** – developed and supported by Oracle MySQL team

Disadvantages

- **Planning & Scheduling** – robust solution that requires planning and scheduling

The chart below summarizes the various attributes of all of the backup methods that have been discussed. MySQL Enterprise Backup provides a robust set of features and the flexibility to implement a strong data retention policy based on your customized needs.

	mysqlpump/ mysqldump	LVM Snapshots	MySQL Replication	MySQL Enterprise Backup
Full Backup	✓	✓	✓	✓
Incremental Backup	✗	✓	✗	✓*
Partial Backup	✓	✗	✗	✓
Compression	✗	✗	✗	✓*
Encryptions Entire Backup Image	✗	✗	✗	✓
Allows Updates	✗	✗	✓	✓*
Point-in-time Consistency	✗	✓	✓	✓*
Verify Backups	✗	✗	✓	✓
Backup Speed	Poor	Good	Very Good	Very Good
Recovery Speed	Very Poor	Good	Very Good	Very Good
Partial Restore	✓	✗	✗	✓
Corruption Detection	✓	✗	✗	✓
Meets Regulatory Archive Requirements	✓	✗	✗	✓
Meets Security Requirements	✓	✗	✗	✓
Supports DDL	✓	✗	✗	✓

* For InnoDB



Examples

The MySQL Enterprise Backup documentation includes numerous examples of mysqlbackup commands for performing Full, Incremental, Partial, Restores and more.

MySQL Enterprise Backup Users Guide:

<http://dev.mysql.com/doc/mysql-enterprise-backup/4.1/en/index.html>

mysqlbackup Command Reference

<http://dev.mysql.com/doc/mysql-enterprise-backup/4.1/en/mysqlbackup.html>

Example: Backing Up an Entire Instance

<http://dev.mysql.com/doc/mysql-enterprise-backup/4.1/en/mysqlbackup.backup.html>

Example: Making an Incremental Backup

<http://dev.mysql.com/doc/mysql-enterprise-backup/4.1/en/mysqlbackup.incremental.html>

Example: Restoring a Database at its Original Location

<http://dev.mysql.com/doc/mysql-enterprise-backup/4.1/en/mysqlbackup.restore.html>

Conclusion

MySQL Enterprise Backup provides multiple methods for backup and recovery of MySQL databases. It supports full, incremental, partial, encrypted and compressed backups that allow you to perform consistent Point-in-Time Recovery, as well as saving both time and money.

Additional Resources

MySQL Enterprise Backup: Product Information

<http://www.mysql.com/products/enterprise/backup.html>

MySQL Enterprise Backup: Documentation

<http://dev.mysql.com/doc/mysql-enterprise-backup/3.5/en/index.html>

MySQL Backup Forum

<http://forums.mysql.com/list.php?28>

MySQL Backup Forum

<https://blogs.oracle.com/mysqlenterprisebackup>

Download (30 Day Trial)

<http://edelivery.oracle.com>

MySQL Customers and Case Studies

<http://www.mysql.com/customers>

MySQL Enterprise Edition

<http://mysql.com/products/enterprise/>

MySQL Professional Services and Consulting

<http://mysql.com/consulting/>

MySQL for ISVs and OEMs

<http://mysql.com/why-mysql/isv-oem-corner/>